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A STUDY IN GREEK ARCHITECTURAL PROPORTIONS.

THE TEMPLES OF SELINOUS.

It is commonly assumed that Greek architectural proportions varied in such a way from century to century that if we had before us the exact proportions of a building we might infer its approximate position in a chronological series. This assumption is a very fascinating one, since it extends the hope of reducing Greek architectural archæology to the basis of a science of mathematical exactness. And yet it is true that very little pains is usually taken to exhibit tables of measurements and proportions, and reliance is placed upon vague general impressions or upon a very scanty basis of measurements. In a subject in which exact methods of observation are only occasionally applied, it is hardly a matter for surprise that so slender a basis of inference as a single proportional aspect should be accepted as a means of determining the chronological sequence. This is precisely what has happened with the historians of Greek architecture. Krell and Durm, and Julius and Reber, are all followers of that fetich of Greek architectural proportions known as Semper's norm.

It may be well at this point to set forth briefly what is meant by Semper's norm. In his remarkable book, *Der Styl*, first published in 1860–1863, Dr. Gottfried Semper outlines the history of Greek architecture. In this he presents a scheme of proportions, which he is careful to state is a mere means of comparison and not a canon. It is the following: "If we take three average distances from column-axis to column-axis as the basis of a rectangle, whose vertical sides are equal to the height of the order, measured from the level of the top step of the stylobate to the upper level of the cornice (excluding the kyma moulding), we thus construct the *normal rectangle*, or in brief, the *norm*, whose measure of length or modulus is the lower radius of the column."[1]

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[1] Semper, *Der Styl*, 2d edit., v. II, pp. 392–395.

According to his view, in this norm all the principal relations and measurements of the system are contained. The norm of a temple, therefore, may be expressed as a fraction, thus:— $\frac{\text{3 average axis-widths}}{\text{height of column} + \text{entablature}}$; or, numerically, the norm of the oldest temple at Selinous is $\frac{16.5}{(9 + 4.55) = 13.5}$.

Applying this norm, he finds six stages in the history of the Doric style, which he characterizes as—

1. Proto-Doric.
2. Lax-archaic Doric (VII cent. B. C.).
3. Strong-archaic Doric (VI cent. B. C.).
4. Developed Doric (V cent. B. C.).
5. Attic Doric (V cent. B. C.).
6. Late Doric or Macedonian (IV cent. B. C.).

These divisions have been substantially followed by his successors.

In criticism of this norm we make two remarks: First, in the fractional form given by Semper the norm is unpractical. It is too difficult to compare fraction with fraction. A whole series of such fractions leaves the mind in a confused condition. Even Semper himself does not attempt to make close comparisons, and his successors are easily led to draw false conclusions. Thus, Semper is satisfied in assigning temples to general classes, without applying his norm so as to establish a serial order of individual temples. Krell (*Ges. d. Dorischen Styls*, 1870), while he expresses more exactly the successive stages of the norm from the horizontal rectangle to a square, and then to a vertical rectangle, nevertheless makes erroneous comparisons of individual norms.

Our second remark concerning Semper's norm is that it is insufficient. It makes no account of ground-plan proportions in general, assuming the inter-axial columnar widths to be the only important variable, and it makes nothing of elevation proportions in general, assuming the total height of the order to be the only important measurement. The distinction between column and entablature in Semper's norm has no functional value and might as well have been omitted. The insufficiency of Semper's norm is practically admitted by the group of writers we have mentioned. Krell tabulates other proportions, but does not utilize them; Durm follows the same course.

A method analogous to that of Semper is followed by Benndorf in his work *Die Metopen von Selinunt*, 1873. He places the temples of Selinous in a series of chronological classes. One of his criteria involves proportions, not taken, however, from the elevation, but exclusively from the ground-plan. According to this norm, narrow temple cellas are early, wide cellas are late. To this we reply, as to Semper: a single proportional aspect is a slender basis of inference. Special causes may have operated to produce a wide cella in early times, or a narrow one in late, without materially affecting the general proportions of the period.

It is important, therefore, for us to inquire whether a single proportional aspect may not be accepted as of some, however slight, value as a norm, and whether the addition of many proportional aspects may not furnish us a norm of much greater value.

In order to limit our attention to a series of monuments, of which careful measurements have been taken, I have selected for comparison the five hexastyle Doric temples at Selinous, designated by Hittorff, in his *Architecture Antique de la Sicile*, Paris, 1870, as temples C, D, S, R, and A. Should the inquiry prove fruitful in the case of these temples, which are of the same general style and found in the same locality, similar modes of comparison might be established for temples of other styles or of the same style as modified by other local peculiarities. In the following tables I have presented first the measurements in metres. These have been compiled from the plates and text of Hittorff. In a few cases, to which I have attached a question mark, the measurements are hypothetical; in other cases they seem to be the result of careful observation.

GROUND-PLAN MEASUREMENT.

	C.	D.	S.	R.	A.
Stylobate breadth,	24.025	23.718	24.402	25.298	16.445
“ length,	63.862	55.183	61.754	67.829	40.790
“ surface,	1534.285	1308.830	1506.920	1715.938	670.792
Cella breadth (ext.),	10.503	9.538	9.282	14.262	9.023
“ length,	40.683	38.277	40.687 (?)	50.000 (?)	29.504 (?)
“ surface,	427.293	365.086	377.657 (?)	713.100 (?)	266.451 (?)
Pronaos length,	6.858	7.442	7.750 (?)	9.500 (?)	4.881
Thesauros “	27.016	19.211	28.250 (?)	24.500 (?)	13.142
Adyton “	6.040	10.990	5.000 (?)	7.237	6.475
Pteroma breadth,	6.761	7.090	7.560	5.518	3.637

ELEVATION MEASUREMENTS.

	C.	D.	S.	R.	A.
Height of krepidoma,	2.221	1.571	1.056	1.936	1.314
“ “ column,	8.623	7.512	9.110	10.187	6.235
“ “ entablature,	4.258	4.092	3.961	4.510	2.791
“ “ architrave,	1.760	1.581	1.516	1.759	1.105
“ “ frieze,	1.489	1.482	1.492	1.721	1.051
“ “ cornice,	1.009	1.029	0.953	1.030	0.635
“ “ pediment,	3.070	3.840	3.620	3.300	2.150
“ “ temple = col. + entab.	12.881	11.604	13.071	14.697	9.026
Breadth of triglyphs,	1.110	1.013	1.012	0.975	0.636
“ “ metopes,	1.123	1.209	1.250	1.380	0.902
Three axis widths	13.262	13.200	13.816	13.500 (?)	9.128 (?)

COLUMN MEASUREMENTS.

	C.	D.	S.	R.	A.
Height of shaft	7.587	6.578	8.230	8.853	5.428
" " capital (+ abacus)	1.036	.934	.880	1.334	.807
" " neck of capital	.326	.218	.222	.271	.213
" " echinus	.324	.357	.324	.555	.319
" " abacus	.386	.359	.334	.508	.275
Upper diameter of column	1.502	1.149	1.245	1.796	1.058
Lower " " "	1.944	1.669	1.818	2.229	1.342
Breadth of abacus	2.522	2.224	2.410	2.818	1.652
Front intercolumniation	2.477	2.731	2.682	2.376	1.701

ENTABLATURE MEASUREMENTS.

	C.	D.	S.	R.	A.
Breadth of entablature	23.483	23.006	23.618	24.762	16.095
" " frieze	"	"	"	"	"
" " cornice	24.797	24.100	25.300	26.670	17.407
" " pediment	"	"	"	"	"
Length " entablature	63.260	54.471	60.970	67.293	40.440

From these measurements, which are made in metres and fractions of metres, we derive the following tables of proportions. These proportions, it will be observed, concern the ground-plan, the elevation, the columns and the entablature, including the gables or pediments. Some of these proportions, it will be observed, resemble Semper's norm in being expressible as quadrangles. The first proportion, for example, gives the quadrangle of the stylobate. Others may be designated as linear proportions, since they express the relations between lines. The second of the ground-plan proportions, giving the relation of the length of the cella to the length of the stylobate, is of this character. All of the proportions here given are either linear or rectangular. Both kinds of proportions we have regarded as important, though for present purposes it is unnecessary to group them separately. More fully expressed, the first of these proportions would read as follows: Breadth of stylobate : Length of stylobate = x : 1. The value of x is found by dividing the first term of the proportion by the second, and it is these values which we have expressed numerically in our tables. A considerable number of such proportions are tabulated by Hittorff (calculated by his son Charles) in *Livre Septième* of the text, but no systematic use is made of them as norms to determine the chronological sequence of the temples.

GROUND-PLAN PROPORTIONS.

	C.	D.	S.	R.	A.
1. B. of stylobate ÷ L. of stylobate,	.376	.430	.395	.373	.403
2. L. of cella ÷ L. of stylobate,	.637	.694	.659 (?)	.737 (?)	.723 (?)
3. B. of cella (exter.) ÷ B. of stylobate,	.437	.402	.386	.564	.549
4. B. of cella ÷ L. of cella,	.258	.249	.228 (?)	.285 (?)	.306 (?)
5. Surface of cella ÷ surface of stylobate,	.278	.279	.251 (?)	.416 (?)	.397 (?)
6. L. of pronaos ÷ L. of cella,	.168	.194	.191 (?)	.190 (?)	.166
7. L. of thesauros ÷ L. of cella,	.664	.502	.694 (?)	.490 (?)	.445
8. L. of adyton ÷ L. of cella,	.148	.287	.123 (?)	.145	.219
9. B. of pteroma ÷ lower diameter,	3.478	4.248	4.159	2.476	2.710

ELEVATION PROPORTIONS.

	C.	D.	S.	R.	A.
10. Height of krepidoma ÷ H. of Temple,	.173	.135	.088	.132	.146
11. " column ÷ H. of Temple,	.669	.647	.697	.693	.691
12. " entablature ÷ H. of Temple,	.331	.353	.303	.307	.309
13. " architrave ÷ " "	.137	.136	.116	.120	.123
14. " frieze ÷ " "	.1156	.128	.101	.1170	.1166
15. Height of cornice ÷ " "	.078	.089	.073	.0701	.0704
16. " pediment ÷ " "	.23834	.331	.277	.225	.23831
17. Breadth of triglyphs ÷ " "	.086	.087	.077	.066	.070
18. " metopes ÷ " "	.087	.104	.096	.094	.100
19. Three axis-widths ÷ " "	1.030	1.138	1.057	.919	1.011
20. Height of temple ÷ B. of stylobate	.5361	.489	.5356	.581	.548
21. " krepidoma ÷ " "	.092	.066	.043	.077	.080
22. " column ÷ " "	.359	.317	.373	.403	.379
23. " entablature ÷ B. of "	.177	.173	.162	.178	.170
24. " architrave ÷ " "	.073	.0667	.062	.070	.0672
25. " frieze ÷ " "	.062	.063	.061	.068	.070
26. " cornice ÷ " "	.040	.043	.0391	.041	.0386
27. " pediment ÷ " "	.128	.162	.148	.130	.131
28. " entablature ÷ H. of column,	.494	.545	.435	.443	.448
29. Height of Temple ÷ L. of stylobate,	.202	.210	.212	.217	.221

COLUMN PROPORTIONS.

	C.	D.	S.	R.	A.
30. Height of shaft ÷ Height of column,	.879	.876	.905	.868	.871
31. “ capital ÷ H. of column,	.120	.124	.097	.131	.129
31. “ neck of capital ÷ H. of column,	.038	.029	.024	.027	.034
33. “ echinus ÷ “ “	.038	.048	.036	.054	.051
34. “ abacus ÷ “ “	.045	.048	.037	.049	.044
35. “ column ÷ lower diameter,	4.436	4.501	5.011	4.570	4.646
36. “ shaft ÷ “ “	3.903	3.941	4.526	3.976	4.045
37. “ capital ÷ “ “	.533	.560	.484	.598	.601
38. “ abacus ÷ “ “	.199	.215	.184	.228	.205
39. Upper diameter of column ÷ lower diameter,	.773	.688	.685	.806	.788
40. Lower “ “ ÷ H. of Temple,	.151	.144	.139	.152	.149
41. Upper “ “ ÷ “ “	.117	.099	.095	.122	.118
42. Height of abacus ÷ Breadth of abacus,	.153	.161	.139	.180	.166
43. “ capital ÷ “ “	.411	.420	.365	.473	.489
44. Lower diameter of col. ÷ average front intercolumniation,	.785	.611	.678	.938	.789

ENTABLATURE PROPORTIONS.

	C.	D.	S.	R.	A.
45. Height of architrave ÷ Height of entablature	.413	.386	.383	.390	.396
46. “ frieze ÷ “ “	.350	.362	.377	.382	.376
47. “ cornice ÷ “ “	.237	.252	.241	.2283	.2275
48. “ entablature ÷ Breadth “	.181	.178	.168	.182	.173
49. “ frieze ÷ “ “	.0634	.064	.0631	.070	.065
50. “ cornice ÷ B. of cornice,	.041	.043	.038	.039	.036
51. “ pediment ÷ B. of pediment,	.1238	.159	.143	.1237	.1235
52. “ triglyphs ÷ B. of triglyphs,	1.341	1.463	1.474	1.265	1.653
53. “ metopes ÷ B. of metopes,	1.326	1.226	1.194	1.247	1.165
54. Breadth of triglyphs ÷ B. of metopes,	.988	.838	.810	.707	.705
55. Height of entablature ÷ L. of entablature	.067	.074	.064	.066	.068

Having tabulated these proportions in such a form that their values may be readily compared, let us assume that the chronological series would exhibit an ascending or descending series of these numerical values. It would be evidently an arbitrary assumption should we adopt in every case an ascending series or the reverse. We need, therefore, some external assistance to guide us in determining the nature of the sequence. This assistance we may obtain in the general assumption that temples C and D are early, and that R and A are late. We here take it for granted that the form, mode of construction, sculptures, etc., of C and D are more archaic than those of R and A, without assuming the individual priority of C to D or of R to A. By the aid of this general assumption, when C and D are found to have higher values than R and A, our proportion may be arranged in a descending series. When C and D have smaller values, the series is an ascending one. Applying, therefore, our general assumption to each series of proportions considered as a norm, we reach the following results:

GROUND-PLAN NORMS.

On the following assumptions, the chronological sequence becomes:

1.	Assume a narrow stylobate to be early,	R	C	S	A	D
2.	“ “ short cella “ “	C	S(?)	D	A(?)	R(?)
3.	“ “ narrow “ “ “	S	D	C	R	A
4.	“ “ “ “ “ “	S(?)	D	C	R(?)	A (?
5.	“ “ small “ “ “	S(?)	C	D	A(?)	R(?)
6.	“ “ long pronaos “ “	D	S(?)	R(?)	C	A
7.	“ “ “ thesauros “ “	S(?)	C	D	R(?)	A
8.	“ “ “ adyton “ “	D	A	C	R	S(?)
9.	“ “ broad pteroma “ “	D	S	C	A	R

ELEVATION NORMS.

10.	Assume a high krepidoma to be early,	C	A	D	R	S
11.	“ “ low column “ “	D	C	A	R	S
12.	“ “ high entablature “ “	D	C	A	R	S
13.	“ “ “ architrave “ “	C	D	A	R	S
14.	“ “ “ frieze “ “	D	R	A	C	S
15.	“ “ “ cornice “ “	D	C	S	A	R
16.	“ “ “ pediment “ “	D	S	C	A	R
17.	“ broad triglyphs “ “	D	C	S	A	R
18.	“ narrow metopes “ “	C	R	S	A	D

19.	Assume broad axis-widths to be early,	D	S	C	A	R
20.	“ low temple “ “	D	S	C	A	R
21.	“ high krepidoma “ “	C	A	R	D	S
22.	“ low column “ “	D	C	S	A	R
23.	“ high entablature “ “	R	C	D	A	S
24.	“ “ architrave “ “	C	R	A	D	S
25.	“ low frieze “ “	S	C	D	R	A
26.	“ high cornice “ “	D	R	C	S	A
27.	“ “ pediment “ “	D	S	A	R	C
28.	“ “ entablature “ “	D	C	A	R	S
29.	“ low side elevation “ “	C	D	S	R	A

COLUMN NORMS.

30.	Assume a long shaft to be early,	S	C	D	A	R
31.	“ “ low capital “ “	S	C	D	A	R
32.	“ “ high neck of capital to be early,	C	A	D	R	S
33.	“ “ low echinus “ “	S	C	D	A	R
34.	“ “ high abacus “ “	R	D	C	A	S
35.	“ “ squat column “ “	C	D	R	A	S
36.	“ “ “ shaft “ “	C	D	R	A	S
37.	“ “ low capital “ “	S	C	D	R	A
38.	“ “ high abacus “ “	R	D	A	C	S
39.	“ “ strong diminution “ “	S	D	C	A	R
40.	“ “ thick column (at base) “ “	R	C	A	D	S
41.	“ “ slender “ (at summit) “ “	S	D	C	A	R
42.	“ “ low abacus “ “	S	C	D	A	R
43.	“ “ “ capital “ “	S	C	D	R	A
44.	“ “ wide intercolumniation “ “	D	S	C	A	R

ENTABLATURE NORMS.

45.	Assume a high architrave to be early,	C	A	R	D	S
46.	“ “ low frieze “ “	C	D	A	S	R
47.	“ “ high cornice “ “	D	S	C	R	A
48.	“ “ “ entablature “ “	R	C	D	A	S
49.	“ “ “ low frieze “ “	S	C	D	A	R
50.	“ “ “ cornice “ “	D	C	R	S	A
51.	“ “ “ pediment “ “	D	S	C	R	A
52.	“ “ broad triglyphs “ “	C	D	S	A	R
53.	“ “ narrow metopes “ “	C	R	D	S	A
54.	“ “ broad triglyphs “ “	C	D	S	R	A
55.	“ “ high entablature on long side of temple to be early,	D	A	C	R	S

In explanation of this table of norms, it is to be observed that such terms as “high” and “low” are to be interpreted by means of the standards of comparison used at the time. Thus a "high" and a "low" frieze, a "high" and a "low" abacus, a "long" and a "squat" shaft, are all assumed to be early, but these members are described as high or low, long or squat, in reference to different standards of comparison. The standards used are the denominators or second terms of comparison given in the tables of proportions.

In regard to the usefulness of such tables of proportions, and their application as norms, it may be broadly affirmed that whenever we are entitled to assume a gradual growth or decline, without reactions, such tables give us at least the means of measuring the amount of growth or decline that has taken place in some particular member. But if we are inclined to make any one of these norms, such as Semper's (No. 19) or Benndorf's (No. 3) the guiding principle for the determination of the sequence, we have merely to glance at the fifty-four other chronological norms and see how different is the result according to our choice. Which one of these fifty-five norms shall be king? For us it is impossible to select any one as the determining norm, since we cannot assume that Greek architects were, like Semper, interested only in one class of proportions.

The second question which we raised above is a more difficult one. May there not be some combination of norms, sufficiently representative to be practically determinative of the question at issue? Even if we admit that special causes may arise to invalidate the claims of any particular norm, is there not some method of reaching an exact numerical ratio representative of a combination of proportions which may be of practical value in determining a chronological sequence? From the proportions we have already given we might readily select a certain number of norms and combine them, but in the presence of the rest how could we justify the right of this aristocratic body of norms to rule the rest? Let us then admit to every norm some share in the governing function and count the votes. We thus find, in taking the ballot for the ground-plan norms, that C has 1 vote for the first place (*i. e.*, the oldest temple), 3 votes for second place, 4 votes for third place, 1 vote for fourth place and none for the fifth. In this form it is difficult to compare the votes for one temple with those for another, so we may consider the votes as fractions of a common denominator and add them. It seems to be convenient in the present case to adopt the number 15 as a common denominator and count a vote for first place as equal to $\frac{5}{15}$, a vote for second place as $\frac{4}{15}$, for third place as $\frac{3}{15}$, for fourth place as $\frac{2}{15}$ and for fifth place as $\frac{1}{15}$. We have then to multiply the votes by the numerators of their corresponding fractions and add the results. The denominator, being the same throughout, may be omitted. Thus the total value of the ground-plan votes of C may be set down as 31, of D as 33, of S as 36, of R as 19 and of A as 16. Applying the same process to all the returns we have the following results:

VOTES.

	Ground-plan.		*Elevation.*		*Column.*		*Entablature.*		*Total.*
C.	31	+	77	+	57	+	46	=	211
D.	33	+	82	+	52	+	43	=	210
S.	36	+	47	+	50	+	28	=	161
R.	19	+	46	+	34	+	26	=	125
A.	16	+	48	+	32	+	22	=	118

From this we gather the following

RESULTS.

The sum of the ground-plan norms favors the sequence	S D C R A
" " " " elevation " " " "	D C A S R
" " " " column " " " "	C D S R A
" " " " entablature " " " "	C D S R A

The sum of all the norms favors the sequence C D S R A.

From this table of results we see how uncertain is the inference even if we gather together into one group a number of norms. The study of the ground-plan produces one result, the elevation another, the columns and entablature a third. A somewhat higher degree of certainty attaches to the sum of all the norms; but even here care must be taken to properly estimate the value of the final sequence. The struggle for first place between C and D is so close that the omission or change of a single norm, even in our long series, would change the final result. Who can say, therefore, from a study of the proportions alone, whether C or D be the earlier temple?

With regard to S, we are on safer ground when we say that S is transitional between C and D on the one hand and R and A on the other; and this is true, whichever of these pairs we assume to be the earlier. In regard to the relative antiquity of R and A, the returns point in favor of the earlier date for temple R. This is a question which has not been raised by the writers on the temples of Selinous, since they have been satisfied in assigning these two temples to the same general class. The measurements and proportions seem, however, to show that the difference between R and A is greater than that between C and D.

In conclusion, we may remark that the determination of chronological sequence by means of the data furnished by proportions is a laborious method of reaching a result which may be sometimes attained more quickly in other ways—but cases may arise when this method may be the only decisive method. For this general purpose, and for the sake of all the special inferences which may be drawn, it is highly to be desired that careful measurements should be made on as comprehensive a scale as possible, and that the relations of these measurements to each other should be tabulated in some such way as we have indicated. Nevertheless, when we come to make use of proportions as norms determinative of chronological sequence, great pains should be taken to make the evidence cumulative, since the smaller the number of norms upon which we rely, the less certain, in general, will be the result.

ALLAN MARQUAND.

Princeton University,
November, 1894.